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(54) **NAVIGATION AID INSTRUMENT FOR AIRCRAFT**

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USPC 340/945, 947–951, 963, 967–979
See application file for complete search history.

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(57) **ABSTRACT**

Navigation aid instrument for an aircraft pilot including:
a first display device (R**3**) extending horizontally, wherein the center of the display device embodies the longitudinal axis (X) of the aircraft, a mobile marker can move on either side of the center of the first display device (R**3**) indicating the aircraft flight direction relative to the ground, and the mobile marker is further away from the center of the display device (R**3**) the further the aircraft drifts from the rectilinear flight path, and/or
two left (R**2**) and right (R**1**) display devices that extend vertically at a distance from each other and have the function of indicating the angle of inclination of the aircraft wings relative to the horizontal respectively on the left side or right side of the aircraft, wherein a mobile marker can move either along the left display device (R**2**), or along the right display device (R**1**) to indicate to the pilot which way his aeroplane is inclined and the value of the inclination is higher the further the mobile marker is away from the top of the left (R**2**) or right (R**1**) display device concerned.

11 Claims, 1 Drawing Sheet

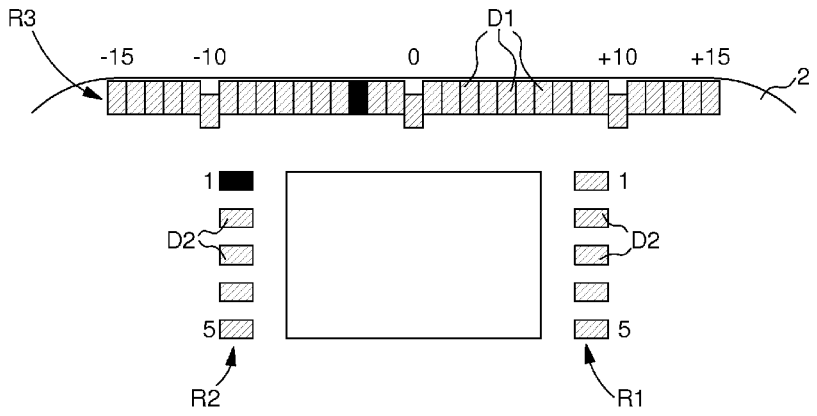

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Fig. 1

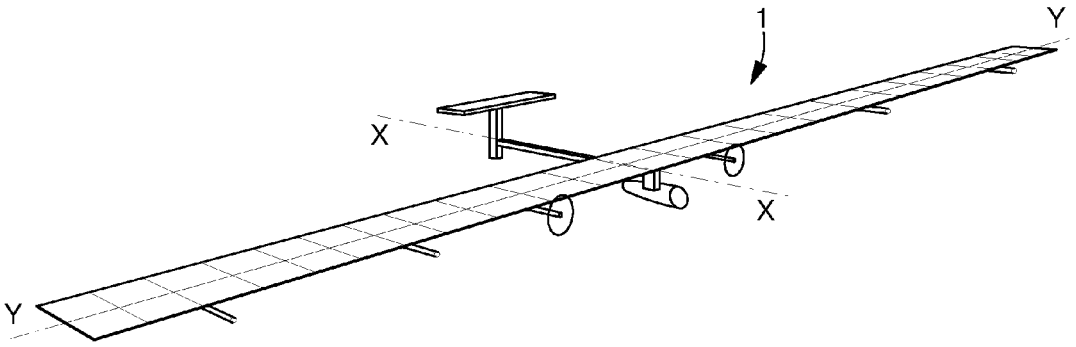


Fig. 2

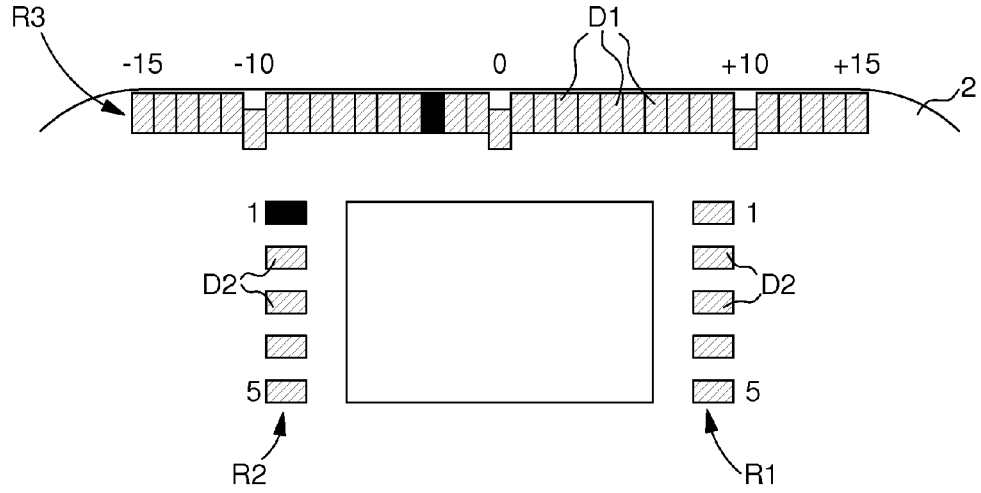
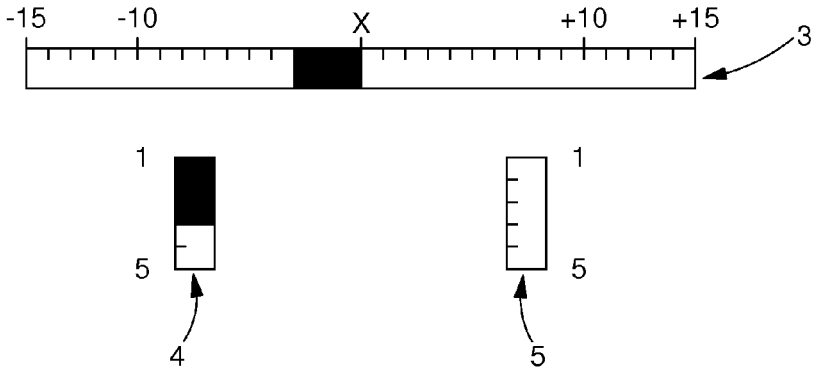


Fig. 3



NAVIGATION AID INSTRUMENT FOR AIRCRAFT

This is a National Phase Application in the United States of International Patent Application PCT/EP2009/064927 filed Nov. 10, 2009, which claims priority on European Patent Application No. 08169905.0 of Nov. 25, 2008. The entire disclosures of the above patent applications are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention concerns a navigation aid instrument for an aircraft. More specifically, the invention concerns an instrument for assisting the pilot of an aircraft during the approach and landing phases.

BACKGROUND OF THE INVENTION

The purpose of the project named Solar Impulse is to fly an aeroplane powered solely by solar energy captured by a multitude of photoelectric cells distributed over the entire surface of the aircraft. To achieve this challenge, the apparatus must be very light and have a large wing span, typically on the order of 61 meters, i.e. a wing span comparable to an Airbus A340 which weighs several hundred tonnes.

It goes without saying that there are enormous differences of control between these two types of aircraft. Without going into detail, it should be noted that the approach and landing phases are fundamentally different for piloting these two types of aircraft. A large heavy aeroplane, which is heavily motorised, has considerably fewer constraints during approach and the final landing phase. In fact, any crosswind, even a relatively strong crosswind, does not cause any great problems of stability, and the angle of approach can easily be corrected since the pilots have the ability to step on the gas and negotiate a slight turn. This being so, even if the technique and power of a large airliner offer a relatively high safety margin, the final approach and landing nonetheless remain complex flight phases requiring the full attention of the pilots, who have to control a large number of parameters within a short period of time.

The Solar Impulse pilot, while having to control the same parameters as in a conventional aircraft, will not have a power reserve enabling him to easily correct the path, particularly in the last hectometers preceding touchdown on the runway. Because of the extremely reduced weight and large wing span of this aircraft, it will be very sensitive to side winds and will only have a very limited possibility for manoeuvre during the final approach. It was therefore necessary to find a way of giving the pilot information relating to the angle of approach and the inclination of the wings of his aircraft.

As regards the angle of approach, it can be said that when an aeroplane wishes to land, it is normally directed towards the threshold of the runway in a straight line. However, it is of course sensitive to crosswinds which may cause it to deviate from its path. This is how, in the event of crosswind, the pilot, if he looks straight ahead, will notice that the runway is slightly to the left, or to the right relative to the nose of the aircraft. The power of the engines of a conventional aircraft will enable the pilot to correct the angle between the rectilinear path and the runway threshold.

For a Solar Impulse type aircraft, the pilot has no power reserve and he must therefore prepare the approach either by adhering as closely as possible to the straight line, or by anticipating the drift of the aircraft due to the crosswind as early as possible. To do so, the pilot, who is already extremely occupied with other approach manoeuvres, must easily be able to see the correction that has to be made to his path in order to approach the runway threshold properly. Moreover, he must also be able to know whether the wing is perfectly horizontal, because, as it is very large, it is liable to touch the runway on landing if it is inclining too far on one side or the other. It should be realised that with a wing span of 61 meters, it is practically impossible for the pilot to visualise an inclination of the wings of one or two meters relative to the perfect horizontal.

SUMMARY OF THE INVENTION

It is an object of the present invention to answer the aforementioned requirements by providing a navigation aid instrument which allows an aircraft pilot to assess, in a simple stroke, the angle of inclination of the wings of his aircraft and the drift relative to the rectilinear direction which will bring him to the runway threshold.

The invention therefore concerns a navigation aid instrument for an aircraft pilot, characterized in that it includes a horizontally extending display device, wherein the centre of said display device embodies the longitudinal axis of the aircraft, a mobile marker that can move on either side of the centre of the display device indicates the flight direction of the aircraft relative to the ground, i.e. the angle formed by the longitudinal axis of said aircraft and the horizontal component of the velocity vector of said aircraft, wherein the angle is positive on the right side of the longitudinal axis of the aircraft, and, the more the aircraft drifts from its rectilinear flight path, the further the mobile marker moves away from the centre of the display device.

According to a complementary feature of the invention, the mobile marker moves on a scale comprised between −15° and +15°.

According to a particular embodiment of the invention, the display device is achieved using a row of light emitting diodes, wherein the centre of said row of diodes embodies the longitudinal axis of the aircraft, and one diode in the row of diodes lights up to the right or left of the central diode to indicate to the pilot the flight direction of the aircraft relative to the ground. The display resolution provided by the row of diodes will be at least ±1° and preferably ±0.4°. It will be clear that this resolution is not absolute. It depends upon the distance between the pilot's head and the instrument. Thus, it is even possible for the resolution to be different for different pilots. One diode in the row of diodes will indicate a drift of one degree between the longitudinal axis of the aircraft and the horizontal component of the velocity vector of said aircraft.

According to another embodiment of the invention, the aircraft navigation aid according to the invention includes two, left and right, vertically extending display devices at a distance from each other and having the function of indicating the angle of inclination of the aircraft wings relative to the horizontal respectively on the left side or right side of said aircraft, wherein the angle of inclination is positive when the aircraft wings are inclined to the right side, and a mobile marker can move either along the left display device, or along the right display device to indicate to the pilot which way his aeroplane is inclined and the value of the inclination.

According to a particular embodiment of the invention, the two, left and right display devices are each made using a row of light emitting diodes, wherein one diode in one of the left or right diode rows lights up to indicate the side on which the aeroplane is inclined and by how many degrees the wings are inclined relative to the horizontal. The display resolution

provided by the two rows of diodes will preferably be ±1°, with one diode of either of the two rows of diodes indicating a one degree inclination of the aircraft. Advantageously, the two vertical left and right display devices supply an indication of the inclination of the wings comprised between 0° and 5°.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the present invention will appear more clearly from the following detailed description of an example embodiment of the navigation aid instrument according to the invention, this example being given solely by way of non-limiting illustration with reference to the annexed drawing, in which:

FIG. **1** is a perspective view of an aircraft fitted with the navigation aid instrument according to the invention;

FIG. **2** is a schematic view of the navigation aid instrument according to the invention including a horizontal row of light emitting diodes for indicating a drift between the longitudinal axis of the aircraft and the horizontal component of the velocity vector of said aircraft and two vertical rows of light emitting diodes for indicating the inclination of the aircraft wings relative to the horizontal on the left side or right side of said aircraft, and

FIG. **3** is a similar view to that of FIG. **2**, where the light emitting diodes are replaced by liquid crystal display cells.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The Solar Impulse pilot will have to keep the angle of inclination of the wings close to zero when flying level and very low (typically less than 5°) in the turns. Moreover, the angle formed by the aeroplane's flight direction relative to the ground must be very precisely controlled. It is sometimes difficult to determine which direction the aeroplane is travelling in, which significantly increases the workload of the pilot, particular during the approach phases. The low speed of the aircraft and the high side slip angle even with a moderate crosswind add additional difficulty. A conventional instrument panel does not provide precise information concerning the angle of inclination and velocity vector direction for properly carrying out all of the flight phases. It has thus been deemed necessary to provide an instrument providing a display of these parameters that is easy to read, in particular a precise indication of the angle of inclination in proximity to zero degrees and the flight direction relative to the ground, to assist the pilot during the final approach to landing.

The angle of inclination will be designated (Φ), i.e. the angle between the transverse axis (Y) of aeroplane **1** (FIG. **1**) and the horizontal plane. Φ is positive when the aircraft leans to the right. Moreover, the side slip angle will be designated (β), in other words the angle between the longitudinal axis (X) of the aircraft and the horizontal component of the air velocity vector. β is positive on the right side of longitudinal axis X of the aircraft. Finally, the angle of drift will be designated (Ω)), i.e. the angle between the horizontal component of the air velocity vector and the runway on the ground. Ω is positive to the right of the air velocity vector.

The main function of the aircraft navigation aid instrument according to the invention is to provide a clear view of the angle of inclination Φ of the aircraft with a precision of one degree for the first five positive or negative degrees of inclination. Beyond 5 degrees, the angle of inclination no longer needs to be indicated by the instrument according to the invention, given that it can be assessed with sufficient precision by the instruments of a conventional instrument panel.

Another function of the aircraft navigation aid instrument according to the invention is that it allows the pilot to monitor and correct the flight direction relative to the ground, or in other words the angle resulting from the sum of the side slip angle β and the drift angle Ω. Only the horizontal component of the velocity vector will be displayed, which will allow the pilot to be informed as to his flight direction in terms of azimuth but not elevation. Finally, the instrument according to the invention must be able to warn the pilot when the angle of inclination Φ reaches 6° (this value can be adjusted as required). This alarm must be both visual and sensory. The alarm will therefore be produced in the vibrating sleeves of the pilot's flight suit. In other words, if the wing leans too far to the right, the right sleeve will vibrate, indicating to the pilot that he must correct the inclination of the left wing.

The pilot must be able to be informed of all the aforementioned parameters (angle of inclination and flight direction) clearly and without any possible source of error, both day and night. This objective can be achieved with suitable sizing and a careful choice of colours and symbols.

The navigation aid instrument according to the invention is based on rows of coloured light emitting diodes arranged on the instrument panel. FIG. **2** below illustrates the desired arrangement.

The rows of light emitting diodes indicating the angle of inclination and flight direction are arranged on the top part of instrument panel **2**. Diodes D**2** dedicated to indicating the angle of inclination are separated by a space of 5 mm. There are five in each row, namely one diode per degree of inclination.

A precise indication of the angle of inclination is provided by two vertical rows of light emitting diodes, a right row R**1** and left row R**2**. One or several diodes, namely one diode per degree of inclination, which play the part of a mobile marker by producing a bright blue light, will light up in succession to indicate an inclination of the wing to the left side or right side under the horizon. Thus, if the aeroplane is flying perfectly horizontally, none of diodes D**2** will light up. However, if the right wing of the aircraft is inclined by 3°, three diodes D**2** of right row R**1** will light up in succession and remain lit up until the pilot has re-established the attitude of the aeroplane by correcting the inclination in the opposite direction. The angle of inclination is displayed on a range of ±5°. The number of diodes D**2** lit up from the top of a row R**1**, R**2** indicates the value of the angle in degrees up to 5°. In the example shown in the drawing, the first diode starting from the top of row R**2** of diodes D**2** is lit up, indicating an inclination of 1° of the aircraft wings on the left side.

If the angle of inclination reaches 6° or more (adjustable value), the entire row of five diodes on the right or left side concerned will start to flash at a frequency of 2 Hz and the signal intended to produce the alarm in the vibrating sleeve of the pilot's flight suit will be generated.

Diodes D**1** for supplying a precise flight direction indication are arranged in a horizontal row R**3** arranged above the two rows R**1** and R**2** of diodes D**2**. The flight direction reading precision must not be less than 1°. A diode D**1** is therefore provided for each degree of drift of the aircraft flight direction relative to the ground. The horizontal row R**3** of diodes D**1** will have a pale blue background colour from which a diode D**1**, playing the part of mobile marker, will stand out by indicating in bright green the direction of the horizontal component of the velocity vector relative to the ground. For indication of the velocity vector direction, the measuring range will be ±15° given that the pilot's eyes are around 70 cm from the instrument panel **2** and that the top right part of the panel measures 35 cm. For flight directions greater than 15° relative

to the longitudinal axis of the aircraft, the bright green diode will remain lit up permanently at the end of row R3 of diodes D1 on the appropriate side. The diode marking the zero in row R3 of diodes D1 and the diodes marking −10° and +10° in the same row R3 of diodes D1 could be staggered (see FIG. 2) for example downwards to provide visual markings to the pilot. In the example shown in the drawing, it is seen that the third diode to the left of the centre of row R3 of diodes D1 is lit up, indicating therefore a drift of −3° of the longitudinal axis X of the aircraft relative to the rectilinear flight direction.

In flight, all of the diodes will be dark, with the exception of:

horizontal row R3 of diodes D1 which will always be illuminated in a pale blue colour, thus providing the pilot with a lateral reference axis

one diode D1 of horizontal diode row R3 will indicate in bright green the direction of flight (if the aircraft is flying in a perfectly rectilinear manner only diode D1 at the centre of row R3 will be lit up);

the two vertical rows R1 and R2 of diodes D2 will indicate in a bright blue colour the value of the angle of inclination up to 5°. The five diodes D2 of a given row will flash in blue for an angle of inclination equal to or higher than 6°.

Two dimmer switches are provided, one for adjusting the pale blue background of the horizontal row R3 of diodes D1, and the other for regulating the brightness of the brightest green velocity vector indicator and the brightest blue angle of inclination indicator.

It will be clear that the navigation aid devices according to the invention, based on the use of rows of light emitting diodes could be replaced, for example, by liquid crystal display devices. Thus a liquid crystal display 3 of elongated rectilinear shape could be arranged horizontally indicating the aircraft flight direction relative to the ground, i.e. the angle formed by the longitudinal axis of said aircraft and the horizontal component of the velocity vector of the aircraft. The liquid crystal display could be backlit and light coloured when the aeroplane is flying in a straight line. The liquid crystal display could then gradually get darker from the centre towards the left or right according to whether the aircraft is moving away from the rectilinear path to the left or right. Likewise, two display screens of elongated rectilinear shape 4 and 5 could be arranged vertically indicating the angle of inclination of the aircraft wings relative to the horizontal. These screens could be backlit and light coloured when the aeroplane is flying on the horizontal. One of the two screens would then gradually get darker from the top according to whether the aircraft wings inclining to the right or the left.

The invention claimed is:

1. A navigation aid instrument for an aircraft pilot, comprising:

a first display device that extends horizontally relative to an instrument panel of an aircraft,

wherein the first display device has a centre embodying a longitudinal axis of the aircraft, and a movable mobile marker,

wherein the mobile marker is movable on either side of the centre of the first display device, wherein the mobile marker measures an angle formed by the longitudinal axis of the aircraft and a horizontal component of a velocity vector of the aircraft, thereby indicating a flight direction of the aircraft relative to a ground,

wherein the angle is positive on a right side of the pilot when the pilot is looking at a nose of the aircraft, and

wherein the mobile marker and the centre of the display device are operably connected so that the further away from the centre of the display device that the mobile marker is, the more the aircraft has drifted from a rectilinear flight direction that will lead the aircraft to a runway threshold.

2. The navigation aid instrument according to claim 1, wherein a resolution of the angle displayed by the first display device is ±1° relative to the rectilinear flight direction that will lead the aircraft to the runway threshold, one diode being provided for each degree of drift.

3. The navigation aid instrument according to claim 1, wherein the first display device supplies an indication relating to the aircraft flight direction relative to the ground comprised between −15° and +15°.

4. The navigation aid instrument according to claim 1, wherein the first display device includes a row of light emitting diodes, wherein a centre of the row of diodes embodies the longitudinal axis of the aircraft, and one diode in the row of diodes lights up to a right or left of the centre of the row of diodes, thereby indicating to the pilot the flight direction of the aircraft relative to the ground.

5. The navigation aid instrument according to claim 2, wherein the first display device includes a row of light emitting diodes, wherein a centre of the row of diodes embodies the longitudinal axis of the aircraft, and one diode in the row of diodes lights up to a right or left of the centre of the row of diodes, thereby indicating to the pilot the flight direction of the aircraft relative to the ground.

6. The navigation aid instrument according to claim 3, wherein the first display device includes a row of light emitting diodes, wherein a centre of the row of diodes embodies the longitudinal axis of the aircraft, and one diode in the row of diodes lights up to a right or left of the centre of the row of diodes, thereby indicating to the pilot the flight direction of the aircraft relative to the ground.

7. The navigation aid instrument according to claim 4, wherein one diode in the row of diodes indicates a difference of one degree between the longitudinal axis of the aircraft and the horizontal component of the velocity vector of said aircraft.

8. The navigation aid instrument according to claim 5, wherein one diode in the row of diodes indicates a difference of one degree between the longitudinal axis of the aircraft and the horizontal component of the velocity vector of said aircraft.

9. The navigation aid instrument according to claim 6, wherein one diode in the row of diodes indicates a difference of one degree between the longitudinal axis of the aircraft and the horizontal component of the velocity vector of said aircraft.

10. The navigation aid instrument according to claim 1, wherein the first display device comprises a liquid crystal display cell that is in a light coloured state when the aircraft is flying in a straight line and that gets darker from the centre to the left or to the right according to whether the aircraft is drifting from the rectilinear flight path to the left or to the right.

11. A navigation aid instrument for an aircraft pilot, including a combination of a first display device according to claim 1.

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